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**AN ANALYSIS OF THE AQUATIC INVERTEBRATES AND
HABITAT OF TWO TRIBUTARIES OF THE SHIELDS RIVER:
COTTONWOOD CREEK AND ROCK CREEK**

July-August 2000

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A report to

**The Montana Department of Environmental Quality
Helena, Montana**

by

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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in July and August 2000 from 2 sites on each of 2 streams tributary to the Shields River in Park County, Montana. Aquatic invertebrate assemblages were sampled by personnel of the Montana Department of Environmental Quality (DEQ). Study sites lie within the Montana Valley and Foothill Prairies ecoregion (Woods et al. 1999). A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied is needed to assist in the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to habitat assessment parameters, and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, high water temperatures, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting.

METHODS

Aquatic invertebrates were sampled by Montana DEQ personnel from July 27-August 1, 2000. Two sites were sampled on Rock Creek, and 2 sites were sampled on Cottonwood Creek. Site locations and sampling dates are indicated in Table 1. The sampling method employed was that recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). In addition to aquatic invertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998) for streams with riffle/run prevalence.

Evaluated habitat features include instream conditions, larger-scale channel conditions including flow status, streambank condition, and extent of the riparian zone. Scores were assigned in the field to each habitat measure, and these scores were totaled and compared to the maximum possible score to give an overall assessment of habitat.

Aquatic invertebrate samples and associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses. In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

To assess aquatic invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics, which have been shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998). In addition, they are relevant to the kinds of impacts that are present in the Shields River watershed. They have been demonstrated to be more variable with anthropogenic

Table 1. Sampling sites and dates. Four sites on 2 tributaries of the Shields River. July-August, 2000.

Site designation	Waterbody	Sampling Date	GPS	
			Latitude	Longitude
R-1	Rock Creek	7/28/2000	45°55'32"	110°24'04"
R-2	Rock Creek	7/28/2000	45°53'55"	110°30'26"
C-1	Cottonwood Creek	7/27/2000	46°00'49"	110°25'14"
C-2	Cottonwood Creek	8/1/2000	45°56'27"	110°31'14"

disturbance than with natural environmental gradients (Bollman 1998). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. Ephemeroptera (mayfly) taxa richness. The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.

2. Plecoptera (stonefly) taxa richness. Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.

3. Trichoptera (caddisfly) taxa richness. Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.

4. Number of sensitive taxa. Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998).

5. Percent filter feeders. Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in

insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* sp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. Percent tolerant taxa. Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998).

<i>metric</i>	<i>Score</i>			
	3	2	1	0
Ephemeroptera taxa richness	> 5	5 - 4	3 - 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 - 5	5.01 - 10	10.01 - 25	> 25
Percent tolerant taxa	0 - 5	5.01 - 10	10.01 - 35	> 35

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the

bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman, unpublished data). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman, unpublished data).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman, unpublished data).

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis, 1997).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

RESULTS

Habitat assessment

Figure 1 compares habitat assessment results for the 4 sites visited. Table 4 itemizes the evaluated habitat parameters and shows the assigned scores for each.

Figure 1. Total habitat assessment scores for 4 sites on 2 tributaries of the Shields River. July-August 2000.

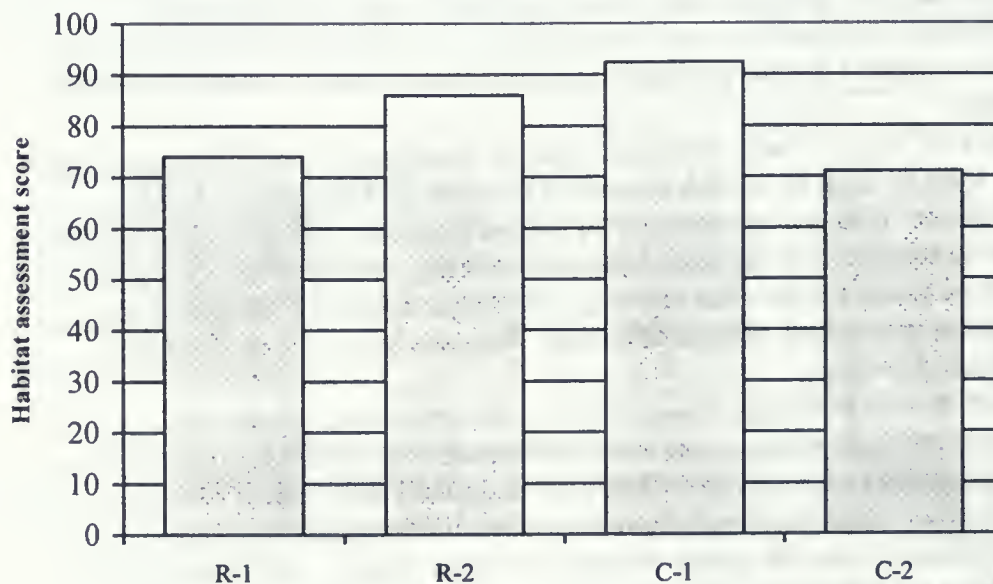


Table 4. Stream and riparian habitat assessment. Four sites on 2 tributaries of the Shields River. July-August 2000.

Max. possible score	Parameter	R-1	R-2	C-1	C-2
10	Riffle development	10	10	10	10
10	Benthic substrate	9	9	10	9
20	Embeddedness	16	18	20	16
20	Channel alteration	20	20	20	18
20	Sediment deposition	11	16	20	11
20	Channel flow status	16	16	20	11
20	Bank stability: left / right	7 / 7	6 / 6	10 / 10	4 / 4
20	Bank vegetation: left / right	7 / 7	9 / 9	9 / 9	6 / 6
20	Vegetated zone: left / right	4 / 4	9 / 9	5 / 5	9 / 9
160	Total	118	137	148	113
	Percent of maximum CONDITION*	74 SUB	86 OPT	92.5 OPT	71 SUB

*Condition categories: Optimal (OPT) > 80% of maximum score; Sub-optimal (SUB) ; 75 - 56%; Marginal (MARG) 49 - 29%; Poor <23%. Adapted from Plafkin et al. 1998

Contrary to expectations, habitat assessment results indicate that conditions were sub-optimal at the upstream site on Rock Creek (R-1) but optimal at the downstream site (R-2). At the upper site, mild sediment deposition was noted and the riparian zone width was judged marginal. At the lower site, streambanks were reported to be moderately stable, but all instream parameters rated optimal scores.

Habitat conditions on Cottonwood Creek appeared to conform to the expected pattern; optimal conditions were reported upstream, but disturbance increased longitudinally and the lower site was assessed as sub-optimal. Still, the riparian zone width was perceived to be in marginal condition at the upstream site, improving longitudinally to optimal conditions at the lower site. Instream habitat parameters were all judged optimal at the upper site, but some sediment deposition was reported at the lower site, probably associated with the moderately unstable streambanks assessed there.

Bioassessment

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled at the 4 sites in this study. Table 5 itemizes each contributing metric and shows individual metric scores for each site. Tables 3a and 3b show criteria for impairment classifications and use-support categories recommended by Montana DEQ.

When this bioassessment method is applied to these data, scores indicate that 3 visited sites (R-1, R-2, and C-2) fully support designated uses. These 3 sites appear to be unimpaired in terms of biotic health. The upper site on Cottonwood Creek (C-1) exhibits

Figure 2. Total bioassessment scores for 4 sites on 2 tributaries of the Shields River. July-August 2000. Sites are described in Table 1. Revised bioassessment metrics and criteria (Bollman 1998) used as reference.

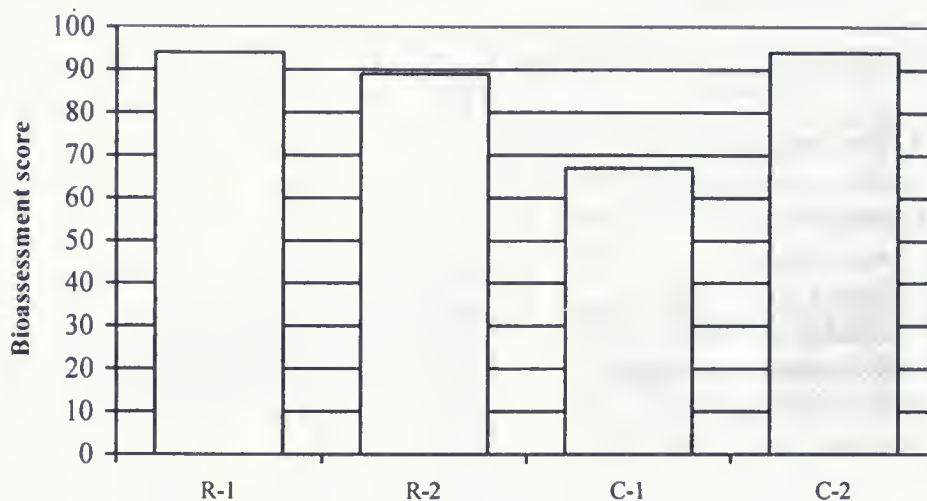


Table 5. Metric values, scores, and bioassessments for 4 sites on 2 tributaries of the Shields River. July-August 2000. Sites are described in Table 1. Revised bioassessment metrics and criteria (Bollman 1998) used as reference.

	SITES			
	R-1	R-2	C-1	C-2
METRICS	METRIC VALUES			
Ephemeroptera richness	11	9	6	6
Plecoptera richness	4	3	1	4
Trichoptera richness	9	10	1	7
Number of sensitive taxa	11	5	2	6
Percent filterers	7	5	0	1
Percent tolerant taxa	3	9	1	7
	METRIC SCORES			
Ephemeroptera richness	3	3	3	3
Plecoptera richness	3	2	1	3
Trichoptera richness	3	3	0	3
Number of sensitive taxa	3	3	2	3
Percent filterers	2	3	3	3
Percent tolerant taxa	3	2	3	2
TOTAL SCORE (max.=18)	17	16	12	17
PERCENT OF MAX.	94	89	67	94
Impairment classification*	NON	NON	SLI	NON
USE SUPPORT †	FULL	FULL	PART	FULL

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3a. † Use support designations: See Table 3b.

signs of slight impairment of biotic health, and partly supports designated uses. The evidence for slight impairment can be discerned in the Plecoptera and Trichoptera taxa richness scores, which are much lower than expected for a valley stream. The site also yielded fewer sensitive taxa than any of the other sites visited.

Aquatic invertebrate communities

Low modified biotic index values (2.46 at R-1 and 3.22 at R-2) and exceptionally high mayfly taxa richness (11 at R-1 and 9 at R-2) characterize both sites on Rock Creek. These indicators of water quality suggest that cold clean water provided an excellent medium for aquatic invertebrates in this stream. Sensitive taxa abounded at both sites, including the dipterans *Glutops* sp. and *Rhabdomastix* sp., the perlodid stonefly *Kogotus* sp., and the caddisfly *Dolophilodes* sp., all of which were collected at both locations. The visited sites supported all of the appropriate functional components expected in a minimally disturbed valley stream. High taxa richness and high predator richness suggest plentiful and diverse instream habitats. Eighteen “clinger” taxa were taken at the upstream site and 20 were present in the sample from the downstream site; fine sediment deposition did not appear to compromise biotic health in Rock Creek.

Water quality indicators suggest unimpaired conditions at both sites on Cottonwood Creek. The modified biotic index values were low at both sites (2.13 at C-1 and 3.55 at C-2) and the mayfly fauna was as diverse as expected for a valley stream. Evidence for habitat disturbance was apparent at the upstream site (C-1), however. The site supported the lowest taxa richness (16) of any site visited, and the lowest diversity of predator taxa, suggesting that instream habitats were limited. Seven “clinger” taxa and a single caddisfly taxon were present in the sample, which may indicate that one source of habitat limitation may have been fine sediment deposition. The dominant taxon in the assemblage was the scraping heptageniid *Epeorus albertae*, which comprised 48% of animals in the sample. The abundance of this mayfly suggests that canopy cover may have been scant at this site. Long-lived taxa were represented by a single individual of the beetle *Optioservus* sp. A dearth of semivoltine taxa may indicate that the site is periodically dewatered.

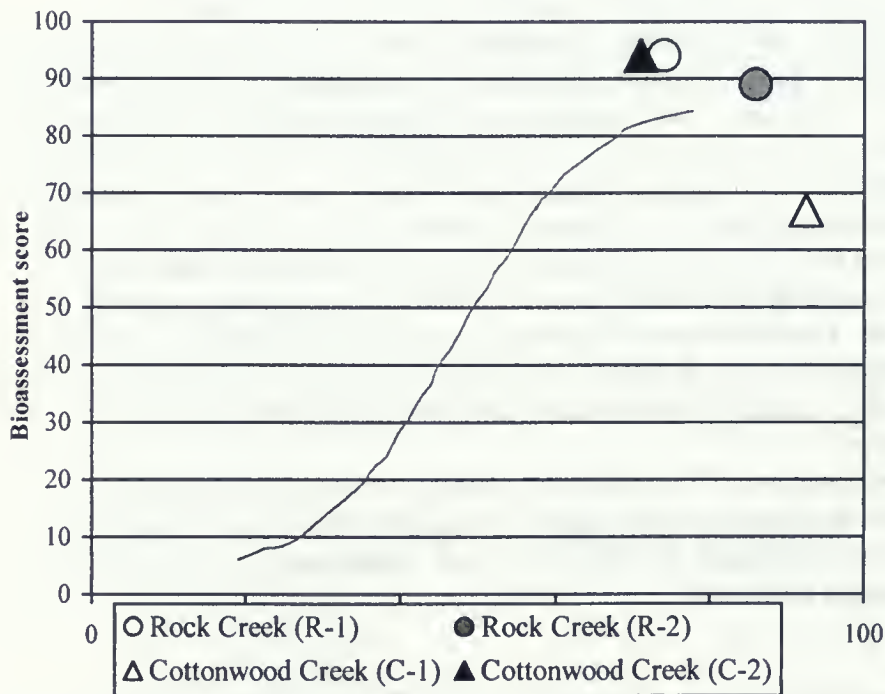
At the downstream site (C-2), high taxa richness (34), high predator diversity (9), and representation of all functional components of a healthy benthic assemblage all suggest that habitat was minimally disturbed at this site. Both small scale and reach scale habitat indicators scored optimally.

CONCLUSIONS

- Minimal disturbance to water and habitat quality is suggested by the taxonomic composition of invertebrate samples taken at both sites on Rock Creek (R-1 and R-2).
- The upper site on Cottonwood Creek (C-1) may be impaired by fine sediment deposition, lack of riparian canopy cover, and possibly also by seasonal dewatering. Water quality appears to be good at the site.
- Like the sites on Rock Creek, the downstream site on Cottonwood Creek (C-2) shows no evidence of disturbance to water quality or habitat integrity in its invertebrate assemblage.

- The relationship between habitat assessment scores and bioassessment scores is illustrated in Figure 3. The red curve in the center of the graph represents the hypothetical relationship between habitat quality and biotic health when habitat degradation is the sole source of impairment to benthic assemblage health (Barbour and Stribling 1991). The cluster of data points in the upper right corner of the graph represents those sites in the study that had a combination of minimally disturbed habitat and minimally degraded water quality (R-1, R-2, C-2). The point representing site C-1 lies below the red line; in some cases, this might suggest that water quality degradation may contribute to the slight impairment to biotic health at the site. Despite this, evidence for water quality problems is not discernible in the data, as described previously in this report.

Figure 3. The relationship of habitat assessment scores and bioassessment scores for sites on tributaries of the Shields River. July-August 2000. The red curve represents the hypothetical relationship between habitat scores and bioassessment scores if habitat quality solely determined biotic health. Light symbols represent upstream sites; dark symbols represent downstream sites.



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APPENDIX

Taxonomic data and summaries

Tributaries of the Shields River

July-August 2000

Aquatic Invertebrate Taxonomic Data

Site Name: Rock Creek

Site ID: Station 1 7/28/2000

Approx. percent of sample used: 100

Taxon	Quantity	Percent	HBI	FFG
<i>Polycelis coronata</i>	2	0.60	4	CG
Total Misc. Taxa	2	0.60		
<i>Acentrella turbida</i>	1	0.30	4	CG
<i>Baetis tricaudatus</i>	10	3.01	6	CG
<i>Drunella coloradensis</i>	24	7.23	0	CG
<i>Drunella doddsi</i>	13	3.92	0	CG
<i>Drunella spinifera</i>	1	0.30	0	PR
<i>Serratella tibialis</i>	7	2.11	2	CG
<i>Cinygmula</i> sp.	88	26.51	4	SC
<i>Epeorus albertae</i>	30	9.04	1	SC
<i>Epeorus longimanus</i>	6	1.81	1	SC
<i>Rhithrogena</i> sp.	13	3.92	0	SC
<i>Ameletus</i> sp.	2	0.60	0	CG
Total Ephemeroptera	195	58.73		
<i>Despaxia augusta</i>	1	0.30	0	SH
<i>Zapada Oregonensis</i> Gr.	3	0.90	2	SH
<i>Doroneuria</i> sp.	2	0.60	1	PR
<i>Kogotus</i> sp.	1	0.30	2	PR
Total Plecoptera	7	2.11		
<i>Parapsyche elsis</i>	3	0.90	1	PR
<i>Glossosoma</i> sp.	35	10.54	1	SC
<i>Dolophilodes</i> sp.	23	6.93	2	CF
<i>Rhyacophila Angelita</i> Gr.	2	0.60	0	PR
<i>Rhyacophila Betteni</i> Gr.	5	1.51	1	PR
<i>Rhyacophila Brunnea</i> Gr.	9	2.71	1	PR
<i>Rhyacophila grandis</i>	2	0.60	1	PR
<i>Rhyacophila Hyalinata</i> Gr.	5	1.51	1	PR
<i>Neothremma</i> sp.	2	0.60	0	SC
Total Trichoptera	86	25.90		
<i>Heterlimnius</i> sp.	4	1.20	4	CG
Total Coleoptera	4	1.20		
<i>Glutops</i> sp.	1	0.30	3	PR
<i>Hexatoma</i> sp.	1	0.30	2	PR
<i>Hesperoconopa</i> sp.	2	0.60	1	UN
<i>Rhabdomastix</i> sp.	1	0.30	3	UN
Total Diptera	5	1.51		
<i>Brillia</i> sp.	1	0.30	5	SH
<i>Eukiefferiella Gracei</i> Gr.	3	0.90	4	OM
<i>Micropsectra</i> sp.	26	7.83	7	CG
<i>Pagastia</i> sp.	3	0.90	1	CG
Total Chironomidae	33	9.94		
Grand Total	332	100.00		

Aquatic Invertebrate Summary Data

Site Name: Rock Creek

Site ID: Station 1 7/28/2000

TOTAL ABUNDANCE 332
Ephemeroptera + Plecoptera +
Trichoptera (EPT) abundance 288

TOTAL NUMBER OF TAXA 34
Number EPT taxa 24

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDANCE	PERCENT
Misc. Taxa	1	2	0.60
Odonata	0	0	0.00
Ephemeroptera	11	195	58.73
Plecoptera	4	7	2.11
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	9	86	25.90
Lepidoptera	0	0	0.00
Coleoptera	1	4	1.20
Diptera	4	5	1.51
Chironomidae	4	33	9.94

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae 8.73

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	11	32	9.64
Parasite	0	0	0.00
Collector-gatherer	10	92	27.71
Collector-filterer	1	23	6.93
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	6	174	52.41
Shredder	3	5	1.51
Xylophage	0	0	0.00
Omnivore	1	3	0.90
Unknown	2	3	0.90

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer 7.57
Scraper/(Scraper + C.filterer) 0.88
Shredder/Total organisms 0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
<i>Cinygmula</i> sp.	88	26.51
<i>Glossosoma</i> sp.	35	10.54
<i>Epeorus albertae</i>	30	9.04
<i>Micropsectra</i> sp.	26	7.83
<i>Drunella coloradensis</i>	24	7.23
SUBTOTAL 5 DOMINANTS	203	61.14
<i>Dolophilodes</i> sp.	23	6.93
<i>Drunella doddsi</i>	13	3.92
<i>Rhithrogena</i> sp.	13	3.92
<i>Baetis tricaudatus</i>	10	3.01
<i>Rhyacophila Brunnea</i> Gr.	9	2.71
TOTAL DOMINANTS	271	81.63

SAPROBIC INDICES

Hilsenhoff Biotic Index 2.46

DIVERSITY MEASURES

Shannon H (loge) 2.34
Shannon H (log2) 3.37
Evenness 0.66
Simpson D 0.10

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	35	10.54
Univoltine	277	83.28
Semivoltine	21	6.17

	#TAXA	ABUNDANCE	PERCENT
Tolerant	1	10	3.01
Intolerant	11	50	15.06
Clinger	18	271	81.63

Aquatic Invertebrate Taxonomic Data

Site Name: Rock Creek

Site ID: Station 2 7/28/2000

Approx. percent of sample used: 100

Taxon	Quantity	Percent	HBI	FFG
<i>Polycelis coronata</i>	1	0.33	4	CG
Total Misc. Taxa	1	0.33		
<i>Acentrella turbida</i>	3	0.98	4	CG
<i>Baetis flavistriga</i>	17	5.54	5	CG
<i>Baetis tricaudatus</i>	15	4.89	6	CG
<i>Serratella tibialis</i>	18	5.86	2	CG
<i>Cinygmula</i> sp.	26	8.47	4	SC
<i>Epeorus albertae</i>	3	0.98	1	SC
<i>Epeorus longimanus</i>	9	2.93	1	SC
<i>Rhithrogena</i> sp.	1	0.33	0	SC
<i>Ameletus</i> sp.	3	0.98	0	CG
Total Ephemeroptera	95	30.94		
<i>Doroneuria</i> sp.	2	0.65	1	PR
<i>Hesperoperla pacifica</i>	12	3.91	2	PR
<i>Kogotus</i> sp.	1	0.33	2	PR
Total Plecoptera	15	4.89		
<i>Arctopsyche grandis</i>	2	0.65	1	PR
<i>Brachycentrus americanus</i>	4	1.30	1	OM
<i>Agapetus</i> sp.	11	3.58	0	SC
<i>Glossosoma</i> sp.	42	13.68	1	SC
<i>Hydropsyche</i> sp.	3	0.98	4	CF
<i>Lepidostoma</i> sp.-sand case larvae	3	0.98	1	SH
<i>Lepidostoma</i> sp.-turret case larvae	4	1.30	2	SH
<i>Dolophilodes</i> sp.	11	3.58	2	CF
<i>Rhyacophila Brunnea</i> Gr.	1	0.33	1	PR
<i>Neophylax splendens</i>	2	0.65	2	SC
Total Trichoptera	83	27.04		
<i>Heterlimnius</i> sp.	5	1.63	4	CG
<i>Lara avara</i>	1	0.33	4	SH
<i>Narpus</i> sp.	5	1.63	4	CG
<i>Optioservus</i> sp.	14	4.56	4	SC
Total Coleoptera	25	8.14		
<i>Ceratopogoninae</i>	1	0.33	6	PR
<i>Chelifera</i> sp.	1	0.33	6	PR
<i>Glutops</i> sp.	2	0.65	3	PR
<i>Rhabdomastix</i> sp.	4	1.30	3	UN
Total Diptera	8	2.61		
<i>Brillia</i> sp.	1	0.33	5	SH
<i>Eukiefferiella Gracei</i> Gr.	27	8.79	4	OM
<i>Micropsectra</i> sp.	7	2.28	7	CG
<i>Pagastia</i> sp.	4	1.30	1	CG
<i>Polypedilum</i> sp.	17	5.54	6	OM
<i>Rheocricotopus</i> sp.	1	0.33	6	OM
<i>Rheotanytarsus</i> sp.	2	0.65	6	CF
<i>Tvetenia</i> sp.	21	6.84	5	CG
Total Chironomidae	80	26.06		
Grand Total	307	100.00		

Aquatic Invertebrate Summary Data

Site Name: Rock Creek

Site ID: Station 2 7/28/2000

TOTAL ABUNDANCE 307
Ephemeroptera + Plecoptera +
Trichoptera (EPT) abundance 193

TOTAL NUMBER OF TAXA 39
Number EPT taxa 22

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDANCE	PERCENT
Misc. Taxa	1	1	0.33
Odonata	0	0	0.00
Ephemeroptera	9	95	30.94
Plecoptera	3	15	4.89
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	10	83	27.04
Lepidoptera	0	0	0.00
Coleoptera	4	25	8.14
Diptera	4	8	2.61
Chironomidae	8	80	26.06

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae 2.41

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	8	22	7.17
Parasite	0	0	0.00
Collector-gatherer	11	99	32.25
Collector-filterer	3	16	5.21
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	8	108	35.18
Shredder	4	9	2.93
Xylophage	0	0	0.00
Omnivore	4	49	15.96
Unknown	1	4	1.30

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer 6.75
Scraper/(Scraper + C.filterer) 0.87
Shredder/Total organisms 0.01

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
<i>Glossosoma</i> sp.	42	13.68
<i>Eukiefferiella</i> Gracei Gr.	27	8.79
<i>Cinygmula</i> sp.	26	8.47
<i>Tvetenia</i> sp.	21	6.84
<i>Serratella tibialis</i>	18	5.86
SUBTOTAL 5 DOMINANTS	134	43.65
<i>Baetis flavistriga</i>	17	5.54
<i>Polypedilum</i> sp.	17	5.54
<i>Baetis tricaudatus</i>	15	4.89
<i>Optioservus</i> sp.	14	4.56
<i>Hesperoperla pacifica</i>	12	3.91
TOTAL DOMINANTS	209	68.08

SAPROBIC INDICES

Hilsenhoff Biotic Index 3.22

DIVERSITY MEASURES

Shannon H (loge) 3.13
Shannon H (log2) 4.51
Evenness 0.85
Simpson D 0.06

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	88	28.66
Univoltine	174	56.51
Semivoltine	46	14.82

	#TAXA	ABUNDANCE	PERCENT
Tolerant	2	29	9.45
Intolerant	5	20	6.51
Clinger	20	178	57.98

Aquatic Invertebrate Taxonomic Data

Site Name: Cottonwood Creek

Site ID: Station 1 7/27/2000

Approx. percent of sample used: 87

Taxon	Quantity	Percent	HBI	FFG
<i>Polycelis coronata</i>	10	2.97	4	CG
Total Misc. Taxa	10	2.97		
<i>Baetis tricaudatus</i>	4	1.19	6	CG
<i>Drunella coloradensis</i>	12	3.56	0	CG
<i>Drunella doddsi</i>	16	4.75	0	CG
<i>Cinygmula</i> sp.	90	26.71	4	SC
<i>Epeorus albertae</i>	160	47.48	1	SC
<i>Ameletus</i> sp.	3	0.89	0	CG
Total Ephemeroptera	285	84.57		
<i>Sweltsa</i> sp.	3	0.89	1	PR
Total Plecoptera	3	0.89		
<i>Rhyacophila Alberta</i> Gr.	9	2.67	0	PR
Total Trichoptera	9	2.67		
<i>Optioservus</i> sp.	1	0.30	4	SC
Total Coleoptera	1	0.30		
<i>Clinocera</i> sp.	2	0.59	6	PR
Total Diptera	2	0.59		
<i>Eukiefferiella Gracei</i> Gr.	4	1.19	4	OM
<i>Pagastia</i> sp.	5	1.48	1	CG
<i>Rheocricotopus</i> sp.	2	0.59	6	OM
<i>Thienemannimyia</i> Gr.	1	0.30	6	PR
<i>Tvetenia</i> sp.	15	4.45	5	CG
Total Chironomidae	27	8.01		
Grand Total	337	100.00		

Aquatic Invertebrate Summary Data

Site Name: Cottonwood Creek

Site ID: Station 1 7/27/2000

TOTAL ABUNDANCE 337
Ephemeroptera + Plecoptera +
Trichoptera (EPT) abundance 297

TOTAL NUMBER OF TAXA 16
Number EPT taxa 8

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDANCE	PERCENT
Misc. Taxa	1	10	2.97
Odonata	0	0	0.00
Ephemeroptera	6	285	84.57
Plecoptera	1	3	0.89
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	1	9	2.67
Lepidoptera	0	0	0.00
Coleoptera	1	1	0.30
Diptera	1	2	0.59
Chironomidae	5	27	8.01

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae 11.00

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	4	15	4.45
Parasite	0	0	0.00
Collector-gatherer	7	65	19.29
Collector-filterer	0	0	0.00
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	3	251	74.48
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	2	6	1.78
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer #DIV/0!
Scraper/(Scraper + C.filterer) 1.00
Shredder/Total organisms 0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
<i>Epeorus albertae</i>	160	47.48
<i>Cinygmula</i> sp.	90	26.71
<i>Drunella doddsi</i>	16	4.75
<i>Tvetenia</i> sp.	15	4.45
<i>Drunella coloradensis</i>	12	3.56
SUBTOTAL 5 DOMINANTS	293	86.94
<i>Polycelis coronata</i>	10	2.97
<i>Rhyacophila Alberta</i> Gr.	9	2.67
<i>Pagastia</i> sp.	5	1.48

TOTAL DOMINANTS 317 94.07

SAPROBIC INDICES

Hilsenhoff Biotic Index 2.13

DIVERSITY MEASURES

Shannon H (loge) 1.30
Shannon H (log2) 1.87
Evenness 0.47
Simpson D 0.25

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	33	9.87
Univoltine	298	88.50
Semivoltine	6	1.63

	#TAXA	ABUNDANCE	PERCENT
Tolerant	2	5	1.48
Intolerant	2	25	7.42
Clinger	7	290	86.05

Aquatic Invertebrate Taxonomic Data

Site Name: Cottonwood Creek

Site ID: Station 2 8/1/2000

Approx. percent of sample used: 13

Taxon	Quantity	Percent	HBI	FFG
<i>Polycelis coronata</i>	9	3.00	4	CG
Total Misc. Taxa	9	3.00		
<i>Baetis tricaudatus</i>	12	4.00	6	CG
<i>Drunella coloradensis</i>	2	0.67	0	CG
<i>Drunella doddsi</i>	9	3.00	0	CG
<i>Drunella grandis</i>	1	0.33	2	CG
<i>Serratella tibialis</i>	17	5.67	2	CG
<i>Cinygmula</i> sp.	5	1.67	4	SC
Total Ephemeroptera	46	15.33		
<i>Sweltsa</i> sp.	1	0.33	1	PR
<i>Despaxia augusta</i>	1	0.33	0	SH
<i>Zapada cinctipes</i>	7	2.33	2	SH
<i>Doroneuria</i> sp.	2	0.67	1	PR
Total Plecoptera	11	3.67		
<i>Arctopsyche grandis</i>	5	1.67	1	PR
<i>Micrasema</i> sp.	2	0.67	1	MH
<i>Glossosoma</i> sp.	19	6.33	1	SC
<i>Apatania</i> sp.	21	7.00	1	SC
<i>Dolophilodes</i> sp.	1	0.33	2	CF
<i>Rhyacophila Angelita</i> Gr.	1	0.33	0	PR
<i>Rhyacophila Brunnea</i> Gr.	2	0.67	1	PR
Total Trichoptera	51	17.00		
<i>Cleptelmis</i> sp.	1	0.33	4	CG
<i>Heterlimnius</i> sp.	7	2.33	4	CG
<i>Narpus</i> sp.	1	0.33	4	CG
<i>Optioservus</i> sp.	7	2.33	4	SC
Total Coleoptera	16	5.33		
<i>Chelifera</i> sp.	1	0.33	6	PR
<i>Clinocera</i> sp.	1	0.33	6	PR
<i>Glutops</i> sp.	1	0.33	3	PR
<i>Caloparyphus</i> sp.	1	0.33	5	CG
<i>Hexatoma</i> sp.	1	0.33	2	PR
Total Diptera	5	1.67		
<i>Eukiefferiella Gracei</i> Gr.	72	24.00	4	OM
<i>Micropsectra</i> sp.	17	5.67	7	CG
<i>Orthocladius</i> sp.	18	6.00	6	CG
<i>Pagastia</i> sp.	11	3.67	1	CG
<i>Polypedilum</i> sp.	8	2.67	6	OM
<i>Stempellinella</i> sp.	7	2.33	4	UN
<i>Tvetenia</i> sp.	29	9.67	5	CG
Total Chironomidae	162	54.00		
Grand Total	300	100.00		

Aquatic Invertebrate Summary Data

Site Name: Cottonwood Creek

Site ID: Station 2 8/1/2000

TOTAL ABUNDANCE	300
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	108
TOTAL NUMBER OF TAXA	34
Number EPT taxa	17

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDANCE	PERCENT
Misc. Taxa	1	9	3.00
Odonata	0	0	0.00
Ephemeroptera	6	46	15.33
Plecoptera	4	11	3.67
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	7	51	17.00
Lepidoptera	0	0	0.00
Coleoptera	4	16	5.33
Diptera	5	5	1.67
Chironomidae	7	162	54.00

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.67
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FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	9	15	5.00
Parasite	0	0	0.00
Collector-gatherer	14	135	45.00
Collector-filterer	1	1	0.33
Macrophyte-herbivore	1	2	0.67
Piercer-herbivore	0	0	0.00
Scraper	4	52	17.33
Shredder	2	8	2.67
Xylophage	0	0	0.00
Omnivore	2	80	26.67
Unknown	1	7	2.33

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	52.00
Scraper/(Scraper + C.filterer)	0.98
Shredder/Total organisms	0.01

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Eukiefferiella Gracei Gr.	72	24.00
Tvetenia sp.	29	9.67
Apatania sp.	21	7.00
Glossosoma sp.	19	6.33
Orthocladius sp.	18	6.00
SUBTOTAL 5 DOMINANTS	159	53.00
Serratella tibialis	17	5.67
Micropsectra sp.	17	5.67
Baetis tricaudatus	12	4.00
Pagastia sp.	11	3.67
Polycelis coronata	9	3.00
TOTAL DOMINANTS	225	72.00

SAPROBIC INDICES

Hilsenhoff Biotic Index	3.55
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DIVERSITY MEASURES

Shannon H (loge)	2.47
Shannon H (log2)	3.56
Evenness	0.70
Simpson D	0.09

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	140	46.50
Univoltine	136	45.33
Semivoltine	25	8.17

	#TAXA	ABUNDANCE	PERCENT
Tolerant	4	21	7.00
Intolerant	6	35	11.67
Clinger	18	110	36.67